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GW Reports Run-on

Inspections

Other: _____

**DATA VALIDATION AND STATISTICAL
EVALUATION OF JUNE 2011
GROUNDWATER QUALITY DATA
CITY OF HELENA LANDFILL**

Prepared For:

**CITY OF HELENA
HELENA, MONTANA**



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consulting scientists and engineers

AUGUST 2011

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DEPT. OF ENVIRO. QUALITY
WASTE & UNDERGROUND TANK
MANAGEMENT BUREAU



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August 30, 2011

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AUG 31 2011

**Dept. of Enviro. Quality
Waste & Underground
Tank Management Bureau**

Mr. Martin Van Oort
Environmental Science Specialist
Solid Waste Regulatory Program
Montana Department of Environmental Quality
P.O. Box 200901
Helena, MT 59620-0901

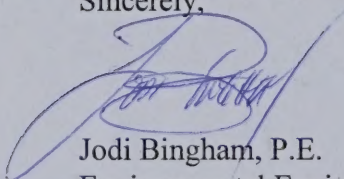
RE: Data Validation and Statistical Evaluation of June 2011 Groundwater Quality Data

Dear Martin,

On behalf of the City of Helena, Hydrometrics validated and statistically evaluated groundwater quality data for samples collected at the City's municipal landfill in June 2011. After receiving approval from John Rundquist of the City of Helena, I am forwarding a copy of the report "Data Validation and Statistical Evaluation of June 2011 Groundwater Quality Data City of Helena Landfill" for your review.

If you have any questions concerning this report, please don't hesitate to call.

Sincerely,



Jodi Bingham, P.E.
Environmental Engineer/Chemist

Enclosure

c: John Rundquist, City of Helena, without Enclosure
Pete Anderson, City of Helena, without Enclosure
Ben Sautter, City of Helena, without Enclosure
Mike Wignot, Hydrometrics, without Enclosure

AUG 31 2011

Dept. of Enviro. Quality
Waste & Underground
Tank Management Bureau

**DATA VALIDATION AND STATISTICAL
EVALUATION OF JUNE 2011
GROUNDWATER QUALITY DATA**

CITY OF HELENA LANDFILL

Prepared for:

Mr. John Rundquist
City of Helena
City/County Building
316 North Park Avenue
Helena, MT 59623

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

August 2011

TABLE OF CONTENTS

LIST OF TABLES	iii
LIST OF FIGURES.....	iii
LIST OF APPENDICES	iii
1. REPORT OBJECTIVES	1-1
2. SITE DESCRIPTION	2-1
2.1 PHYSICAL FEATURES.....	2-1
2.2 WELL LOCATIONS.....	2-1
2.3 GROUNDWATER FLOW DIRECTION AND VELOCITY	2-4
2.4 CURRENT ACTIVITIES.....	2-4
3. SUMMARY OF JUNE 2011 DATA VALIDATION REPORT.....	3-1
4. STATISTICAL DATA EVALUATION AND COMPARISON.....	4-1
4.1 DOWNGRAIDENT WATER QUALITY COMPARISONS WITH CRITERIA AND UPGRADIENT WATER QUALITY	4-1
4.2 INTER-WELL PREDICTION INTERVAL ANALYSIS	4-7
4.3 TREND ANALYSIS	4-9
4.4 TEMPORAL CONCENTRATION PLOTS.....	4-10
4.5 CROSS-GRADIENT DATA EVALUATION	4-14
5. IRRIGATION WELL AND DOMESTIC WELL DATA EVALUATION.....	5-1
6. SUMMARY AND CONCLUSIONS	6-1
7. REFERENCES	7-1

LIST OF TABLES

TABLE 2-1. GROUNDWATER VELOCITIES	2-5
TABLE 4-1. SUMMARY OF PARAMETER CONCENTRATIONS IN LANDFILL MONITORING WELLS FOR THE JUNE 2011 MONITORING EVENT	4-2
TABLE 4-2. COMPARISON OF DOWNGRAIENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS AND MCLs FOR THE JUNE 2011 SAMPLING EVENT	4-3
TABLE 4-3. COMPARISON OF DOWNGRAIENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS AND MCLs FOR ALL SAMPLING EVENTS TO DATE	4-4
TABLE 4-4. RESULTS OF INTER-WELL PREDICTION INTERVAL TESTS	4-8
TABLE 4-5. RESULTS OF MANN-KENDALL TREND ANALYSES	4-9

LIST OF FIGURES

FIGURE 2-1. VICINITY MAP	2-2
FIGURE 2-2. STUDY AREA AND JUNE 2011 POTENTIOMETRIC SURFACE	2-3
FIGURE 4-1. TEMPORAL TRENDS IN TETRACHLOROETHENE CONCENTRATIONS AT SELECTED MONITORING WELLS	4-11
FIGURE 4-2. TEMPORAL TRENDS IN NITRATE CONCENTRATIONS AT SELECTED MONITORING WELLS	4-13
FIGURE 5-1. TEMPORAL TRENDS IN PCE CONCENTRATIONS IN DOMESTIC AND IRRIGATION WELLS	5-2

LIST OF APPENDICES

APPENDIX A	DATA VALIDATION REPORT
APPENDIX B	STATISTICAL ANALYSIS REPORTS

**DATA VALIDATION AND STATISTICAL
EVALUATION OF JUNE 2011
GROUNDWATER QUALITY DATA
CITY OF HELENA LANDFILL**

1. REPORT OBJECTIVES

This report is prepared on behalf of the City of Helena Landfill to fulfill the groundwater data evaluation requirements provided in Administrative Rules, Montana (ARM) Title 17, Chapter 50. This report provides analytical results for groundwater samples collected at monitoring wells during the June 2011 monitoring event, summarizes, the data validation results and statistically evaluates the data. The samples were collected and analyzed in accordance with the Montana Department of Environmental Quality (MDEQ) approved sampling and analysis plan (Hydrometrics, 2008).

ARM 17.50.708(12) and ARM 17.50.708(13) stipulate the types of statistical data evaluations to be performed on groundwater quality monitoring data from regulated landfills. Federal guidance on conducting statistical evaluations of groundwater data is also available (EPA, 1989; EPA, 1992). These regulations and guidance documents allow the use of a wide range of statistical procedures including: parametric analysis of variance, non-parametric analysis of variance, tolerance or prediction interval testing, trend tests, or other statistical tests meeting the statistical testing objectives of the rules.

Statistical evaluations have been performed for this site semiannually since 1993 and the following conclusions have been reached based on the results of those evaluations:

- Chlorinated hydrocarbons occur downgradient of the landfill;
- Tetrachloroethene (PCE) is the chlorinated organic compound of greatest concern due to Maximum Contaminant Level (MCL) exceedances;

- downgradient of the landfill at similar levels.

2. SITE DESCRIPTION

2.1 PHYSICAL FEATURES

A site location map is provided in Figure 2-1. The landfill is surrounded for several miles in all directions by residential, commercial and industrial zoned property. There are several businesses upgradient of the landfill, which have the potential to affect groundwater quality in the area.

A site plan is shown on Figure 2-2. The landfill is divided into three sections. The southern part of the landfill (Phase I and Phase II sections) is unlined and was in operation until the early 1980s. The northern part of the landfill (Phase III) is also unlined, and was in operation until November 1993. The Phase III landfill was capped with an 18-inch clay cover to minimize surface water percolation through the landfill and subsequent migration of chemicals into groundwater.

2.2 WELL LOCATIONS

Fourteen monitoring wells located around the landfill were included in the June 2011 groundwater monitoring program and are characterized as follows:

- Background wells: HL-06-1, HL-94-1R, HL-94-2R, MPC-5;
- Downgradient wells: HL-10-1 (replaced HL-90-1), HL-90-2, HL-90-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3; and
- Cross-gradient well: HL-94-3.

As discussed in Section 3.0 and in accordance with the approved sampling and analysis plan (Hydrometrics, 2008), fourteen of these wells were sampled during the June sampling event. A new compliance well, HL-10-1, located just west of well HL-90-1, was drilled in May 2010 and completed at greater depth than HL-90-1 to provide more reliable sampling and has replaced HL-90-1 in the sampling schedule. Well EPA-1 was damaged during construction activities as discussed in Section 2.4 and could not be sampled during the June 2011



NO SCALE

CITY OF HELENA LANDFILL
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EVALUATION OF JUNE 2011
GROUNDWATER QUALITY DATA

VICINITY MAP

FIGURE

2-1



SITE CODE	DTWL	MPE	SWL
Jun-11			
HL-06-1	15.96	3993.62	3977.66
82-3	66.89	3973.51	3906.62
EPA-1	46.28	3981.08	3934.80
EPA-4	no access	3973.83	
HL-10-1	55.29	3943.01	3887.72
HL-90-1	54.65	3942.48	3887.83
HL-90-2	46.48	3950.96	3904.48
HL-90-3	59.62	3958.29	3898.67
HL-94-1R	57.36	3994.04	3936.68
HL-94-2R	31.60	3967.64	3936.04
HL-94-3	35.18	3967.38	3932.20
HL-99-1	54.10	3943.15	3889.05
HL-99-2	89.10	3945.75	3856.65
HL-99-3	66.24	3948.05	3881.81
INF. GALLE	6.14	3918.89	3912.75
I-1	63.59	3899.59	3836.00
MPC-1	22.60	3946.08	3923.48
MPC-2	16.95	3936.09	3919.14
MPC-5	55.38	3990.14	3934.76



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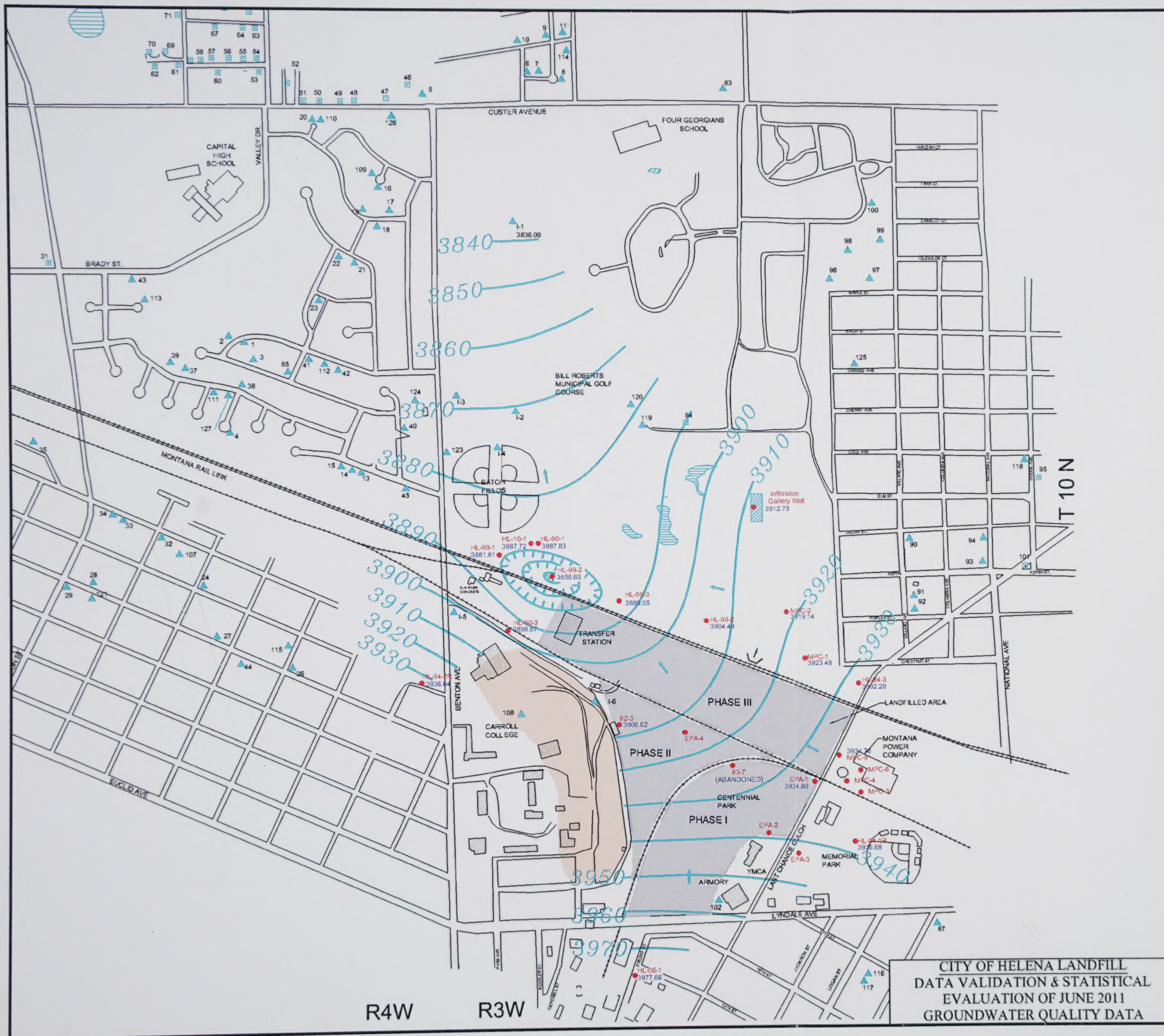
LEGEND

- HL-1 ■ PIEZOMETER
- 83-6 ● MONITORING WELL
- 1-6 ▲ IRRIGATION WELL
- 80 □ DOMESTIC WELL
- INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
- AREA OF SHALLOW LOW PERMEABILITY BEDROCK
- POTENTIOMETRIC CONTOUR LINE
- INFERRED GROUNDWATER FLOW DIRECTION
- STORM WATER OUTFALL FOR LAST CHANCE GULCH

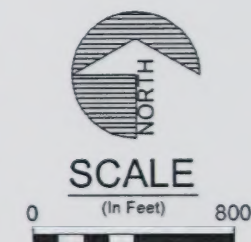
STUDY AREA AND JUNE 2011
POTENTIOMETRIC SURFACE

FIGURE

2-2



SITE CODE	DTWL	MPE	SWL
Jun-11			
HL-06-1	15.96	3993.62	3977.66
82-3	66.89	3973.51	3906.62
EPA-1	46.28	3981.08	3934.80
EPA-4	no access	3973.83	
HL-10-1	55.29	3943.01	3887.72
HL-90-1	54.65	3942.48	3887.83
HL-90-2	46.48	3950.96	3904.48
HL-90-3	59.62	3958.29	3898.67
HL-94-1R	57.36	3994.04	3936.68
HL-94-2R	31.60	3967.64	3936.04
HL-94-3	35.18	3967.38	3932.20
HL-99-1	54.10	3943.15	3889.05
HL-99-2	89.10	3945.75	3856.65
HL-99-3	66.24	3948.05	3881.81
INF. GALLE	6.14	3918.89	3912.75
I-1	63.59	3899.59	3836.00
MPC-1	22.60	3946.08	3923.48
MPC-2	16.95	3936.09	3919.14
MPC-5	55.38	3990.14	3934.76



- LEGEND**
- HL-1 ■ PIEZOMETER
 - 83-8 ● MONITORING WELL
 - I-8 ▲ IRRIGATION WELL
 - 80 □ DOMESTIC WELL
 - INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
 - AREA OF SHALLOW LOW PERMEABILITY BEDROCK
 - 3900 — POTENTIOMETRIC CONTOUR LINE
 - INFERRED GROUNDWATER FLOW DIRECTION
 - ↓ STORM WATER OUTFALL FOR LAST CHANCE GULCH

CITY OF HELENA LANDFILL
DATA VALIDATION & STATISTICAL
EVALUATION OF JUNE 2011
GROUNDWATER QUALITY DATA

STUDY AREA AND JUNE 2011
POTENTIOMETRIC SURFACE

FIGURE
2-2

sampling event. This well has since been repaired and will be included in the next scheduled sampling event. The locations of these wells are shown in Figure 2-2.

2.3 GROUNDWATER FLOW DIRECTION AND VELOCITY

Figure 2-2 shows water level elevations observed in June 2011 and groundwater potentiometric surface contours. Groundwater flow direction is also shown on this figure. The general groundwater flow direction in the vicinity of the landfill is to the north-northwest. The potentiometric surface in the area of well HL-94-3 suggests that groundwater flows to the west northwest (Figure 2-2); thus, well HL-94-3 is not considered to be upgradient or downgradient of the landfill. Well HL-94-3 has, therefore, been designated as a “cross-gradient” well.

Table 2-1 shows the groundwater velocities calculated for each of the monitoring wells sampled during the June 2011 sampling event. Slope was determined from the potentiometric contours shown in Figure 2-2. The hydraulic conductivities were obtained from the groundwater flow model inputs included in the report “Evaluation of Groundwater Extraction Remediation Alternative at the Helena Landfill” (Hydrometrics, 1999a). The porosity for each well was assumed to be 0.25. An average regional gradient of 0.0233 ft/ft was determined between monitoring well HL-06-1 and I-1. This yields an average regional velocity of 0.757 ft/day.

2.4 CURRENT ACTIVITIES

New modifications to Centennial Park, located over the old landfill, began in June 2010 and will continue through the end of the summer of 2011. Construction work included the installation of fill material and some utilities, planting of new grass and trees, and the installation of a new automatic watering system and other park facilities. All modifications to the park were reviewed to ensure the integrity of the landfill cap would be maintained and that the final design would be even more protective of human health and the environment than the current design. All plans were submitted to MDEQ prior to construction. Every effort is

TABLE 2-1. GROUNDWATER VELOCITIES

Well	Hydraulic Conductivity (ft/day)	Slope (ft/ft)	Velocity (ft/day)
EPA-1	2.8	0.0208	0.234
HL-06-1	0.03	0.0369	0.00443
HL-10-1	20	0.0270	2.16
HL-90-1	20	0.0270	2.16
HL-90-2	5.6	0.0278	0.622
HL-90-3	0.03	0.0793	0.00951
HL-94-1R	2.8	0.0119	0.133
HL-94-2R	0.28	0.0385	0.0431
HL-94-3	2.8	0.0168	0.188
HL-99-1	10	0.0160	0.641
HL-99-2	20	0.0714	5.71
HL-99-3	20	0.0683	5.47
I-1	20	0.0233	1.86
Infiltration Gallery	5.6	0.0261	0.585
MPC-1	2.8	0.0203	0.227
MPC-2	2.8	0.0229	0.257
MPC-5	2.8	0.0201	0.225

being made to preserve the existing monitoring wells and the corrective measures previously implemented.

Well EPA-1 was damaged during construction activities. During the June 2011 sampling event, it was noted that although water level measurements could be taken, a bailer would no longer drop to the static water level of the well. Later, personnel from Hydrometrics and Helena Sand and Gravel were able to repair the well and the use of a bailer is again possible. This well will be sampled again during the next scheduled sampling event.

- Monitoring wells 12-3 (SWL only), EPA-1 (SWL only), HL-06-1, HL-18-1, HL-90-1 (SWL only), HL-90-2, HL-90-3, HL-90-4, HL-94-1R, HL-94-2R, HL-94-3, HL-95-1, HL-95-2, HL-95-3, MPC-1, MPC-2, MPC-3;
- Irrigation wells 1-1 (SWL only) and 1-2;
- Domestic wells 5, 16, 40, 48, 52, 57, 63, 90; and
- The infiltration gallery.

The June analytical parameters included metals, volatile organics, semi-volatile organics, halogenated organics, and major anions for all the monitoring wells except MPC-2 and volatile organics, semi-volatile organics, and halogenated organics for all remaining domestic and irrigation wells as specified in the approved sampling and analysis plan (Hydrometrics, 2008).

The water samples collected for the City of Helena Landfill in June 2011 have been validated by the Hydrometrics Data Validation Department in accordance with the project work plan, "Ground Sampling and Analysis Plan: City of Helena Landfill, Groundwater, Surface Water, and Landfill Gas Monitoring Activities" (Hydrometrics, 2008). Lab and field quality control procedures were appropriate; quality control (QC) samples included a field duplicate, a D.L. blank, a trip blank, a reagent blank, and standard internal laboratory QC samples. No parameters were reported as above the reporting limit in the D.L. blank, trip blank, or reagent blank. However, the field duplicate pair collected at HL-90-3 exceeded the control limits for

3. SUMMARY OF JUNE 2011 DATA VALIDATION REPORT

Thirteen monitoring wells around the landfill, seven domestic wells, one irrigation well and the infiltration gallery well were included in the June 2011 sampling event. Well EPA-1 was not sampled due to damage sustained during construction activities as previously discussed. Static water levels (SWL) were obtained from three additional monitoring wells and one additional irrigation well. The June 2011 monitoring sites for the City of Helena Landfill include the following:

- Monitoring wells 82-3 (SWL only), EPA-1 (SWL only), HL-06-1, HL-10-1, HL-90-1 (SWL only), HL-90-2, HL-90-3, HL-94-1R, HL-94-2R, HL-94-3, HL-99-1, HL-99-2, HL-99-3, MPC-1, MPC-2, MPC-5;
- Irrigation wells I-1 (SWL only) and I-4;
- Domestic wells 5, 16, 40, 48, 52, 57, 62, 90; and
- The infiltration gallery.

The June analytical parameters included metals, volatile organics, semi-volatile organics, halogenated organics, and major anions for all the monitoring wells except MPC-2 and volatile organics, semi-volatile organics, and halogenated organics for all remaining domestic and irrigation wells as specified in the approved sampling and analysis plan (Hydrometrics, 2008).

The water samples collected for the City of Helena Landfill in June 2011 have been validated by the Hydrometrics Data Validation Department in accordance with the project work plan, "Revised Sampling and Analysis Plan, City of Helena Landfill, Groundwater, Surface Water and Landfill Gas Monitoring Activities" (Hydrometrics, 2008). Lab and field quality control procedures were appropriate; quality control (QC) samples included a field duplicate, a D.I. blank, a trip blank, a rinsate blank, and standard internal laboratory QC samples. No parameters were reported as above the reporting limit in the D.I. blank, trip blank, or rinsate blank. However, the field duplicate pair collected at HL-90-3 exceeded the control limits for

chemical oxygen demand when compared with EPA guidance. This exceedance resulted in four associated results being flagged. The entire data validation report is included as Appendix A of this report. Overall, the City of Helena Landfill data for June 2011 were deemed acceptable for the purposes of the project as outlined in the work plan.

The infiltration gallery, surface water, and groundwater data were evaluated separately. The four types of data evaluation conducted are:

1. Comparison of applicable water quality criteria and regulatory values against "background" water quality with quarterly sampling of downgradient monitoring wells for June 2011 and all samples to date;
2. Infiltration gallery water quality analysis;
3. Infiltration gallery water quality analysis;
4. Temporal concentration data.

The first data analysis includes all data parameters for which results were reported above the detection limit in any of the monitoring wells for the June 2011 sampling event.

The fourth evaluation, temporal concentration plots, was performed for PCE and nitrate; the only constituents that currently exceed their regulatory limits in downgradient wells. Data from all wells sampled during the June 2011 sampling event were analyzed to determine if PCE results above the detection limit of 1.0 µg/L and nitrate results above the MCL of 10 mg/L are consistently increasing trends were observed.

4.1 DOWNGRADIENT WATER QUALITY COMPARISONS WITH CRITERIA AND UPGRADEMENT WATER QUALITY

The following comparison was derived from the June 2011 data and summary statistics in Tables 4-1, 4-2, and 4-3:

- (a) For the June 2011 sampling event (Tables 4-1 and 4-2), the following parameters were detected only in background wells (upgradient wells) (background wells): 1,1,1-trichloroethane, benzene, bromochloromethane, carbon tetrachloride, and hexachlorobenzene.

4. STATISTICAL DATA EVALUATION AND COMPARISON

Four types of data evaluations were conducted using the June 2011 sample results for the monitoring wells around the landfill; cross-gradient well HL-94-3 is evaluated separately. The infiltration gallery, irrigation well, and domestic wells are also evaluated separately. The four types of data evaluations conducted are:

1. Comparisons of applicable water quality criteria and upgradient (also called “background”) water quality with summary statistics of downgradient concentrations for June 2011 and all samples to date;
2. Inter-well prediction interval analysis;
3. Trend analysis; and
4. Temporal concentration plots.

The first three analyses include all those parameters for which results were reported above the detection limit in any of the monitoring wells for the June 2011 sampling event.

The fourth evaluation, temporal concentration plots, was performed for PCE and nitrate; the only constituents that currently exceed their regulatory limits in downgradient wells. Data from all wells sampled during the June 2011 sampling event which have historically shown PCE results above the detection limit of 0.001 mg/L and nitrate results above the MCL of 10 mg/L or with potentially increasing trends were evaluated.

4.1 DOWNGRADIENT WATER QUALITY COMPARISONS WITH CRITERIA AND UPGRADIENT WATER QUALITY

The following conclusions are derived from the June 2011 data and summary statistics in Tables 4-1, 4-2, and 4-3:

- (a) For the June 2011 sampling event (Tables 4-1 and 4-2), the following parameters were detected only in background (also called upgradient) wells: arsenic, selenium, 1,1,1-trichloroethane, benzene, bromodichloromethane, o-xylenes and total xylenes.

TABLE 4-1. SUMMARY OF PARAMETER CONCENTRATIONS IN LANDFILL MONITORING WELLS
FOR THE JUNE 2011 MONITORING EVENT

Parameter	Downgradient Wells										Upgradient Wells				Cross-Gradient Well	MCL ⁽¹⁾
	HL-10-1	HL-90-2	HL-90-3	MPC-1	MPC-2	HL-99-1	HL-99-2	HL-99-3	HL-06-1	MPC-5	HL-94-1R	HL-94-2R	HL-94-3			
pH (s.u.)	7.1	7.6	7.2	7.2	NM	7.2	7.4	7.5	7.0	7.1	7.5	7.6	7.6	NA		
Specific Conductance (µmhos/cm)	1230	657	1060	1100	NM	1260	864	937	1060	2340	937	817	944	NA		
Sulfate	130	40	120	190	NM	180	110	150	110	560	82	34	160	NA		
Chloride	98	28	54	47	NM	78	44	47	33	17	28	43	89	NA		
Nitrate+Nitrite as N	9.8	0.77	6.7	11.2	NM	10.3	6.3	9.1	5.4	16.4	0.54	3.3	12.4	10		
Arsenic (Dissolved)	<0.005	<0.005	<0.005	<0.005	NM	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.013	<0.005	0.010		
Iron (Dissolved)	<0.03	<0.03	<0.03	0.03	NM	<0.03	<0.03	0.03	<0.03	1.17	<0.03	<0.03	<0.03	0.3 ⁽²⁾		
Selenium (Dissolved)	<0.005	<0.005	<0.005	<0.005	NM	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	0.05		
1,1,1-Trichloroethane	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0024	<0.001	<0.001	<0.001	<0.001	0.2		
1,1-Dichloroethane	0.0017	<0.001	<0.001	0.0031	0.0010	<0.001	0.0013	0.0022	<0.001	<0.001	<0.001	<0.001	<0.001	NA		
Benzene	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0056	<0.001	<0.001	<0.001	0.005		
Bromodichloromethane	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0020	<0.001	<0.001	0.010		
Chloroform	<0.001	<0.001	<0.001	0.0017	<0.001	0.0024	0.0013	0.0021	<0.001	<0.001	0.013	0.0045	0.0040	0.07		
Cis-1,2-Dichloroethene	0.0017	<0.001	<0.001	0.0036	<0.001	0.0016	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.07		
Dichlorodifluoromethane	0.0013	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0013	<0.001	<0.001	<0.001	<0.001	<0.001	1		
Total Xylene	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0019	<0.001	<0.001	<0.001	10		
O-Xylene	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0012	<0.001	<0.001	<0.001	10 ⁽³⁾		
Tetrachloroethene (PCE)	0.0064	<0.001	<0.001	0.010	0.0011	0.0029	0.0034	0.0051	<0.001	<0.001	<0.001	<0.001	<0.001	0.005		
Trichloroethene (TCE)	0.0015	<0.001	<0.001	0.0028	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005		
Cyanide (Total)	<0.005	<0.005	<0.005	0.062	NM	0.091	0.40	0.076	<0.005	7.5	<0.005	<0.005	0.097	0.2		
Chemical Oxygen Demand (COD)	3	3	3	<1	NM	<1	4	5	<1	24	7	4	3	NA		

Concentrations are in mg/L, except as indicated.

NM = not measured

(1) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies.

NA indicates no MCL has been promulgated.

(2) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(3) MCL is for Total Xylenes

Values in **bold** exceed the MCL.

TABLE 4-2. COMPARISON OF DOWNGRAIDENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS
AND MCLs FOR THE JUNE 2011 SAMPLING EVENT

Parameter	June 2011 Downgradient Well Concentrations (mg/L) ⁽¹⁾						Comparison Values (mg/L)			
	D.F. ⁽³⁾	Min.	Mean ⁽⁴⁾	Median	Max.	Max. Location	Background / Upgradient Wells ⁽²⁾			MCL ⁽⁵⁾
							D.F. ⁽³⁾	Mean ⁽⁴⁾	Median	
pH (s.u.)	7/7	7.1	7.31	7.2	7.6	HL-90-2	4/4	7.30	7.3	7.6
Specific Conductance (µmhos/cm)	7/7	657	1015.4	1060	1260	HL-99-1	4/4	1288.5	998.5	2340
Sulfate	7/7	40	131.4	130	190	MPC-1	4/4	196.5	96.0	560
Chloride	7/7	28	56.6	47	98	HL-10-1	4/4	30.3	30.5	43
Nitrate+Nitrite as N	7/7	0.77	7.74	9.1	11.2	MPC-1	4/4	6.41	4.4	16.4
Arsenic (Dissolved)	0/7	<0.005	<0.005	<0.005	<0.005	NA	1/4	0.0070	<0.005	0.013
Iron (Dissolved)	2/7	<0.03	0.030	<0.03	0.030	MPC-1	1/4	0.315	<0.03	1.2
Selenium (Dissolved)	0/7	<0.005	<0.005	<0.005	<0.005	NA	1/4	0.0050	<0.005	0.005
1,1,1-Trichloroethane	0/8	<0.001	<0.001	<0.001	<0.001	NA	1/4	0.0014	<0.001	0.0024
1,1-Dichloroethane	5/8	<0.001	<u>0.0015</u>	<u>0.0012</u>	<u>0.0031</u>	MPC-1	0/4	<0.001	<0.001	<0.001
Benzene	0/8	<0.001	<0.001	<0.001	<0.001	NA	1/4	0.0022	<0.001	0.0056
Bromodichloromethane	0/8	<0.001	<0.001	<0.001	<0.001	NA	1/4	0.0013	<0.001	0.0020
Chloroform	5/8	<0.001	0.0015	0.0015	0.0024	HL-99-1	2/4	0.0049	0.0028	0.013
Cis-1,2-Dichloroethene	3/8	<0.001	0.0015	<0.001	0.0036	MPC-1	0/4	<0.001	<0.001	<0.001
Dichlorodifluoromethane	2/8	<0.001	<u>0.0011</u>	<0.001	0.0013	HL-99-3	0/4	<0.001	<0.001	1
Total Xylene	0/8	<0.001	<0.001	<0.001	<0.001	NA	1/4	0.0012	<0.001	0.0019
O-Xylene	0/8	<0.001	<0.001	<0.001	<0.001	NA	1/4	0.0011	<0.001	0.0012
Tetrachloroethene (PCE)	6/8	<0.001	0.0039	0.0032	0.010	MPC-1	0/4	<0.001	<0.001	<0.001
Trichloroethene (TCE)	2/8	<0.001	<u>0.0013</u>	<0.001	0.0028	MPC-1	0/4	<0.001	<0.001	<0.001
Cyanide (Total)	3/7	<0.005	0.092	<0.005	0.40	HL-99-2	1/4	1.88	<0.005	7.5
Chemical Oxygen Demand (COD)	5/7	<1	2.86	3	5.0	HL-99-3	3/4	9.0	5.5	24

(1) Downgradient wells are: HL-10-1, HL-90-2, HL-90-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3.

(2) Background / Upgradient wells are: HL-06-1, MPC-5, HL-94-1, HL-94-2.

(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.

(4) Means calculated using the detection limit for non-detected sample results.

(5) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies. NA indicates no MCL has been promulgated.

(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(7) MCL is for Total Xylenes

Values in **bold** exceed the MCL. Underlined values exceed the maximum background/upgradient concentration.

TABLE 4-3. COMPARISON OF DOWNGRAIDENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS
AND MCLs FOR ALL SAMPLING EVENTS TO DATE

Parameter	Period of Record Downgradient Well Concentrations (mg/L) ⁽¹⁾					Comparison Values (mg/L)			
	D.F. ⁽³⁾	Min.	Mean ⁽⁴⁾	Median	Max.	D.F. ⁽³⁾	Background / Upgradient Wells ⁽²⁾		MCL ⁽⁵⁾
	250/250	6.8	7.43	7.4	8.1		Mean ⁽⁴⁾	Max.	
pH (s.u.)	250/250	6.8	7.43	7.4	8.1	126/126	7.47	8.1	NA
Specific Conductance (µmhos/cm)	240/240	632	1068	1010	2550	122/122	1383	4170	NA
Sulfate	250/250	15	138	131	345	126/126	274	1980	NA
Chloride	250/250	2	55.4	43	262	125/126	45.4	250	NA
Nitrate+Nitrite as N	227/229	<0.05	7.41	7.8	16.9	121/121	11	73	10
Arsenic (Dissolved)	5/250	<0.005	0.005	<0.005	0.028	49/129	0.007	<0.005	0.1
Iron (Dissolved)	57/250	<0.03	0.081	<0.03	1.69	44/126	0.313	<0.03	3.14
Selenium (Dissolved)	5/250	<0.005	0.005	<0.005	0.006	39/129	0.006	<0.005	0.027
1,1,1-Trichloroethane	57/373	<0.001	0.001	<0.001	0.007	14/133	0.001	<0.001	0.006
1,1,1-Dichloroethane	227/373	<0.001	0.002	0.001	0.007	0/133	<0.001	<0.001	NA
Benzene	2/373	<0.001	0.001	<0.001	0.003	27/133	0.005	<0.001	0.077
Bromodichloromethane	0/373	<0.001	<0.001	<0.001	0.002	11/133	0.001	<0.001	0.005
Chloroform	264/373	<0.001	0.002	0.002	0.016	100/133	0.005	0.037	0.07
Cis-1,2-Dichloroethene	98/350	<0.001	0.001	<0.001	0.011	0/128	<0.001	<0.001	0.07
Dichlorodifluoromethane	158/373	<0.001	0.002	<0.001	0.016	0/133	<0.001	<0.001	1
Total Xylene	1/142	<0.001	0.001	<0.001	0.002	10/53	0.004	<0.001	10
O-Xylene	3/348	<0.001	0.001	<0.001	0.002	27/128	0.003	<0.001	10 ⁽⁷⁾
Tetrachloroethene (PCE)	269/373	<0.001	0.007	0.005	0.094	0/133	<0.001	<0.001	0.005
Trichloroethene (TCE)	155/373	<0.001	0.001	<0.001	0.007	0/133	<0.001	<0.001	0.005
Cyanide (Total)	78/257	<0.005	0.015	<0.005	0.4	29/133	1.08	<0.005	10.9
Chemical Oxygen Demand (COD)	166/248	<1	4.23	3	26	102/127	12.6	75	NA

(1) Downgradient wells are: HL-10-1, HL-90-1, HL-90-2, HL-90-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3.

(2) Background / Upgradient wells are: 83-6, HL-06-1, MPC-5, HL-94-1, HL-94-2.

(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.

(4) Means calculated using the detection limit for non-detected sample results.

(5) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies.

NA indicates no MCL has been promulgated.

(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(7) MCL is for Total Xylenes

Values in **bold** exceed the MCL. Underlined values exceed the maximum background/upgradient concentration.

Parameters detected in only downgradient wells include: 1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, tetrachloroethene (PCE), and trichloroethene (TCE).

- (b) The parameter historically detected only in background wells (Table 4-3) is bromodichloromethane. Parameters historically detected only in downgradient wells include: 1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, and TCE.
- (c) Nitrate, arsenic, iron, benzene, PCE and cyanide were reported at concentrations exceeding MCL criteria in the June 2011 sampling event (Tables 4-1 and 4-2). The MCL for arsenic was exceeded in a single upgradient well (HL-94-2R); the MCL for benzene was exceeded in a single upgradient well (MPC-5); the MCL for PCE was exceeded in three downgradient wells (HL-10-1, MPC-1 and HL-99-3); the MCL for cyanide was exceeded in a single downgradient well (HL-99-2) and a single upgradient well (MPC-5); nitrate exceeded its MCL in two downgradient wells (HL-99-1 and MPC-1), one upgradient well (MPC-5), and cross-gradient well HL-94-3; the secondary MCL (based on aesthetic properties rather than human health standards) for iron was exceeded in a single upgradient well (MPC-5).
- (d) Historically in these wells, nitrate, arsenic, iron, benzene, PCE, TCE, and cyanide have been reported at concentrations exceeding MCL criteria (Table 4-3). The MCLs for PCE and TCE have been exceeded in only downgradient wells; nitrate, arsenic and iron have exceeded their MCLs in both upgradient and downgradient wells; and the MCLs for benzene and cyanide have been exceeded in only upgradient wells. The June 2011 data is generally consistent with these trends with the exception of cyanide. This is the first time the MCL for cyanide has been exceeded in a downgradient well.
- (e) Nitrate was detected in all of the June 2011 samples. The MCL of 10.0 mg/L was exceeded in one sample collected in upgradient well (MPC-5) and in two samples collected from downgradient wells (HL-99-1 and MPC-1). Monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a decrease in the nitrate concentration in this well and is currently at a level of 16.4 mg/L. Discussions with MPC representatives

revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may have inadvertently increased nitrate concentration in area groundwater. This pilot program was shut down when these adverse affects became apparent. However, nitrate levels in downgradient wells have slowly been increasing since that time.

- (f) Metals and arsenic concentrations in groundwater samples have historically been low (typically below laboratory detection limits). Arsenic was detected only in upgradient well HL-94-2R; iron was detected in downgradient wells MPC-1 and HL-99-3 and upgradient well MPC-5; selenium was only detected in upgradient well HL-94-1R; and zinc was detected only in downgradient well HL-99-1 during June 2011 monitoring (Table 3-1). The detected arsenic and metal concentrations were all at or near their detection limits except for arsenic in upgradient well HL-94-2R (0.013 mg/L) compared to a detection limit of 0.005 mg/L and iron in upgradient well MPC-5 (1.17 mg/L) compared to a detection limit of 0.03 mg/L. Arsenic exceeded the MCL of 0.01 mg/L in HL-94-2R. Arsenic has historically fluctuated at HL-94-2 with concentrations ranging from <0.005 mg/L to 0.011 mg/L (based on data collected from April 1994 through December 2010). This is the highest concentration of arsenic in this well over the sampling history. Iron exceeded the secondary MCL of 0.3 mg/L (based on aesthetic properties such as taste, odor and staining rather than human health standards) in MPC-5. Iron has historically fluctuated at MPC-5 with concentrations ranging from approximately 0.2 mg/L to 4 mg/L (based on data collected from December 1995 through June 2011).
- (g) During the June 2011 sampling event, several volatile organic compounds (VOCs) were detected in samples from downgradient wells, but not in samples from background wells (1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, and TCE). PCE was the only VOC to exceed its MCL in downgradient wells (HL-10-1, MPC-1 and HL-99-3). 1,1,1-trichloroethane, benzene, bromodichloromethane, o-xylenes and total xylenes were detected only in background wells; benzene was the only VOC to exceed its MCL in upgradient wells (MPC-5). Chloroform was the only VOC detected in samples from both downgradient and

background wells. All detections of chloroform were well below the MCL of 0.07 mg/L.

- (h) Cyanide was detected in four downgradient wells (MPC-1, HL-99-1, HL-99-2 and HL-99-3) and one upgradient well (MPC-5) during the June 2011 sampling event. All detections were well below the MCL of 0.2 mg/L with the exception of upgradient well MPC-5 (6.2 mg/L) and downgradient well HL-99-2 (0.4 mg/L). This is the first time that the cyanide MCL has been exceeded in a downgradient well. Since well HL-99-2 is used for irrigation on Bill Roberts Golf Course, this may be of concern. Cyanide tends to degrade in sunlight and the treatment provided by the retention pond may be sufficient to decrease cyanide to acceptable levels for irrigation. Therefore, cyanide will be added to the monthly sprinkler sampling to determine the concentration of cyanide being land applied on the golf course.

Previous sampling events have shown that cyanide is present at concentrations ranging from approximately 0.77 to 11 mg/L (based on data collected from June 1995 through June 2011) in upgradient well MPC-5. Historically, downgradient detections of cyanide have been well below the MCL indicating that elevated cyanide levels are not attributable to the Helena Landfill (Table 4-3). As noted previously, a coal gasification plant was historically operated east of the landfill site and could be a source of residual cyanide in groundwater upgradient of the landfill.

4.2 INTER-WELL PREDICTION INTERVAL ANALYSIS

An inter-well prediction interval analysis was used to test for statistically significant differences between background and compliance well concentrations for selected parameters (those above the detection limit in any of the monitoring wells for the June 2011 sampling event). Combining all historical data for the background wells, the Shapiro-Francia Test of Normality was performed for each parameter to determine the distribution of the background data. Inter-well parametric prediction intervals were used when the background data were normally or ln-normally distributed. In cases where the background data were not normally or ln-normally distributed, a non-parametric prediction limit was used. All non-detect values were evaluated at zero. Results of the prediction interval test are summarized in Table 4-4.

TABLE 4-4. RESULTS OF INTER-WELL PREDICTION INTERVAL TESTS

Parameter	Background Wells		Downgradient Wells							
	Distribution ⁽¹⁾	Prediction Limit ⁽²⁾	HL-10-1	HL-90-2	HL-90-3	MPC-1	MPC-2	HL-99-1	HL-99-2	HL-99-3
pH (s.u.)	Non-Norm	6.9-8.0	7.1	7.6	7.2	7.2	NM	7.2	7.4	7.5
Specific Conductance (µmhos/cm)	Non-Norm	4036	1230	657	1060	1100	NM	1260	864	937
Sulfate	Non-Norm	1742.7	130	40	120	190	NM	180	110	150
Chloride	Non-Norm	189.25	98	28	54	47	NM	78	44	47
Nitrate+Nitrite as N	Non-Norm	68.3	9.8	0.77	6.7	11.2	NM	10.3	6.3	9.1
Arsenic (Dissolved)	Non-Norm	0.031	<0.005	<0.005	<0.005	<0.005	NM	<0.005	<0.005	<0.005
Iron (Dissolved)	Non-Norm	2.90	<0.03	<0.03	<0.03	0.03	NM	<0.03	<0.03	0.03
Selenium (Dissolved)	Non-Norm	0.010	<0.005	<0.005	<0.005	<0.005	NM	<0.005	<0.005	<0.005
1,1,1-Trichloroethane	Non-Norm	0.0053	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
1,1-Dichloroethane	ND	0.001	0.0017	<0.001	<0.001	0.0031	0.0010	<0.001	0.0013	0.0022
Benzene	Non-Norm	0.064	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Bromodichloromethane	Non-Norm	0.0041	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chloroform	Non-Norm	0.035	<0.001	<0.001	0.0016	0.0017	<0.001	0.0024	0.0013	0.0021
Cis-1,2-Dichloroethene	ND	0.001	0.0017	<0.001	<0.001	0.0036	<0.001	0.0016	<0.001	<0.001
Dichlorodifluoromethane	ND	0.001	0.0013	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0013
Total Xylene	Non-Norm	0.049	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
O-Xylene	Non-Norm	0.028	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Tetrachloroethene (PCE)	ND	0.001	0.0064	<0.001	<0.001	0.010	0.0011	0.0029	0.0034	0.0051
Trichloroethene (TCE)	ND	0.001	0.0015	<0.001	<0.001	0.0028	<0.001	<0.001	<0.001	<0.001
Cyanide (Total)	Non-Norm	10.3	<0.005	<0.005	<0.005	0.062	NM	0.091	0.40	0.076
Chemical Oxygen Demand (COD)	Non-Norm	64.2	3	3	3	<1	NM	<1	4	5

(1) Normality was calculated using the Shapiro-Francia test.

Norm (X%) = data normally distributed at X% level of significance.

In-Norm (X%) = data In-normally distributed at X% level of significance.

Non-Norm = data not normally or In-normally distributed at 95% or 99% level of significance.

ND = all background data below detection limits. Value shown is the detection limit.

(2) Prediction limits calculated as follows:

Normal or In-normal distribution: parametric prediction interval (99% one-sided, two-sided for pH)

Non-normal distribution: non-parametric prediction interval (99% one-sided, two-sided for pH)

ND: any detectable concentrations in compliance wells are considered significant.

Bold values indicate statistically significant results.

NA - not analyzed

Documentation for each of these statistical tests used is included in Appendix B of this report.

As shown on Table 4-4, 1,1-dichloroethane, cis-1,2-dichloroethane, dichlorodifluoromethane, PCE, and TCE have statistically greater concentrations in downgradient wells than upgradient wells.

4.3 TREND ANALYSIS

In addition to evaluating the chemical concentrations in upgradient and downgradient wells around the landfill for the June 2011 sampling event, it is also important to evaluate concentration trends of key constituents over time. Using the Mann-Kendall test, statistical testing for trends was performed for each downgradient exceedance of its respective inter-well prediction interval as discussed in Section 4.2. Spearman's trend test was used to evaluate parameters related to well HL-10-1 due to the low number of samples available for that well. All non-detect values were evaluated as zero to prevent the detection of false trends when parameters are detected at concentrations less than the reporting limit or when the reporting limits have changed over time. The Mann-Kendall test was not performed for well HL-10-1 as there is only a single sample result. The results of these analyses are summarized in Table 4-5. Documentation for these statistical tests is included in Appendix B of this report.

TABLE 4-5. RESULTS OF MANN-KENDALL TREND ANALYSES

Parameter	HL-10-1	MPC-1	MPC-2	HL-99-1	HL-99-2	HL-99-3
1,1-Dichloroethane	No Trend	Decreasing	No Trend		Increasing	No Trend
Cis-1,2-Dichloroethane	No Trend	Increasing		No Trend		
Dichlorodifluoromethane	No Trend					Decreasing
Tetrachloroethene (PCE)	No Trend	No Trend	No Trend	Decreasing	No Trend	Decreasing
Trichloroethene (TCE)	No Trend	No Trend				

*Grayed boxes did not have downgradient exceedances of the respective inter-well prediction interval and therefore a trend analysis was not performed.

Cis-1,2-dichloroethane is showing an increasing trend in MPC-1; according to National Primary Drinking Water Regulations, cis-1,2-dichloroethane is formed as a breakdown product from the reductive dehalogenation of the common industrial solvents TCE and PCE. Dichlorodifluoromethane and PCE are showing decreasing trends in downgradient wells. 1,1-Dichloroethane is showing increasing and decreasing trends in downgradient wells; this compound is a breakdown product of 1,1,1-trichloroethane, historically found primarily in wells upgradient of the Helena landfill.

4.4 TEMPORAL CONCENTRATION PLOTS

This report focuses on concentration trends for PCE and nitrate because they are the only constituents currently exceeding their MCLs in downgradient monitoring wells. PCE was also the focus of the Corrective Measures Assessment for the landfill (Hydrometrics, 1995).

In an attempt to reduce concentrations of PCE in compliance well HL-90-1, the City installed a groundwater extraction system in the spring of 2000 (Hydrometrics, 1999b). This treatment system involves pumping wells HL-99-1, HL-99-2 and HL-99-3 to intercept PCE leaving the landfill, and treating the water to remove VOCs prior to land application on Bill Roberts Golf Course. These wells have been included in groundwater monitoring events along with compliance well HL-90-1, now replaced by HL-10-1, to evaluate the progress of this new groundwater extraction system.

Trends in PCE concentrations over time for the past ten years for selected monitoring wells are shown on Figure 4-1. PCE concentrations exceeded the MCL value of 0.005 mg/L in monitoring wells HL-10-1, MPC-1 and HL-99-3 for June 2011.

Historically, the concentration of PCE in well MPC-1 (now 0.010 mg/L) has fluctuated between 0.0032 mg/L and 0.017 mg/L based on data collected between May 1992 and June 2011 and according to the trend analysis discussed in the previous section, is showing neither an increasing or a decreasing trend. The PCE concentrations in pumping wells HL-99-1, HL-99-2 and HL-99-3 have shown seasonal fluctuations and decreasing trends in HL-99-1

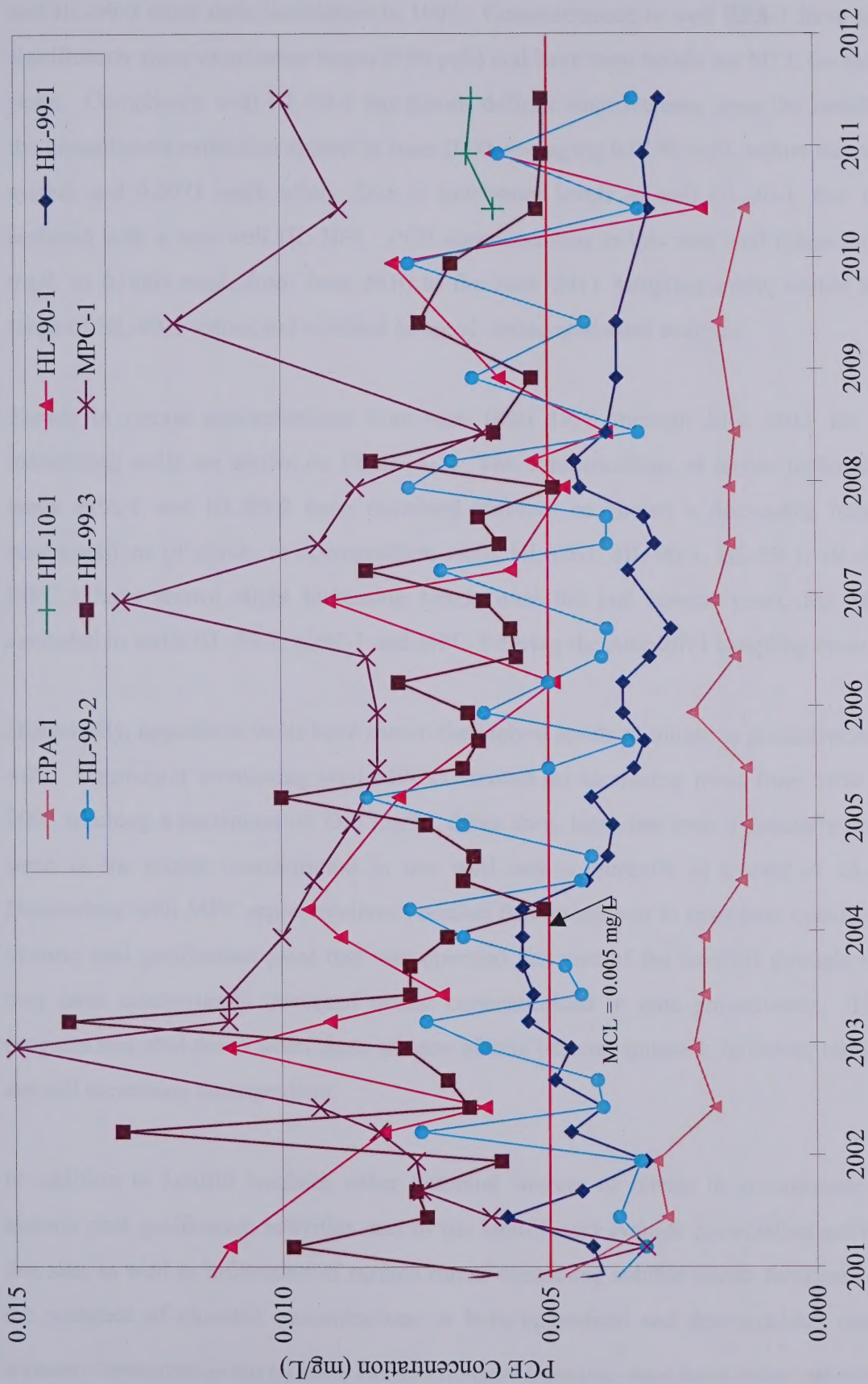


Figure 4-1. Temporal Trends in Tetrachloroethene Concentrations at Selected Monitoring Wells

and HL-99-3 since their installation in 1999. Concentrations in well EPA-1 have decreased significantly since monitoring began (>90 ppb) and have been below the MCL for the last ten years. Compliance well HL-90-1 has shown definite improvement since the installation of the groundwater extraction system in June 2000, averaging 0.0146 mg/L before the extraction system and 0.0073 mg/L after. Due to low water levels in well HL-90-1, this well was replaced with a new well HL-10-1. PCE concentrations in this new well range from 0.006 mg/L to 0.0065 mg/L from June 2010 to the June 2011 sampling event, within historical range of HL-90-1 values and revealed no trend during statistical analysis.

Trends in nitrate concentrations over time from 1999 through June 2011 for selected monitoring wells are shown on Figure 4-2. The concentrations of nitrate in downgradient wells EPA-1 and HL-99-2 have remained constant or shown a decreasing trend. The concentrations of nitrate in downgradient wells HL-06-1, HL-90-3, HL-99-1, HL-99-3 and MPC-1 have shown slight increasing trends over the last several years; the MCL was exceeded in wells HL-99-1, MPC-1 and MPC-5 during the June 2011 sampling event.

Historically, upgradient wells have shown the highest levels of nitrate in groundwater (Figure 4-2). Upgradient monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a generally decreasing trend in the nitrate concentration in this well and is currently at a level of 16.4 mg/L. Discussions with MPC representatives revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may have inadvertently increased nitrate concentrations in area groundwater. This pilot program was shut down when these adverse affects became apparent; however, nitrate levels are still increasing downgradient.

In addition to landfill leachate, other potential sources of nitrate in groundwater include historic coal gasification activities east of the landfill and cyanide remediation activities for this site, as well as infiltration of surface runoff containing soluble nitrate fertilizers. Due to the presence of elevated concentrations in both upgradient and downgradient monitoring

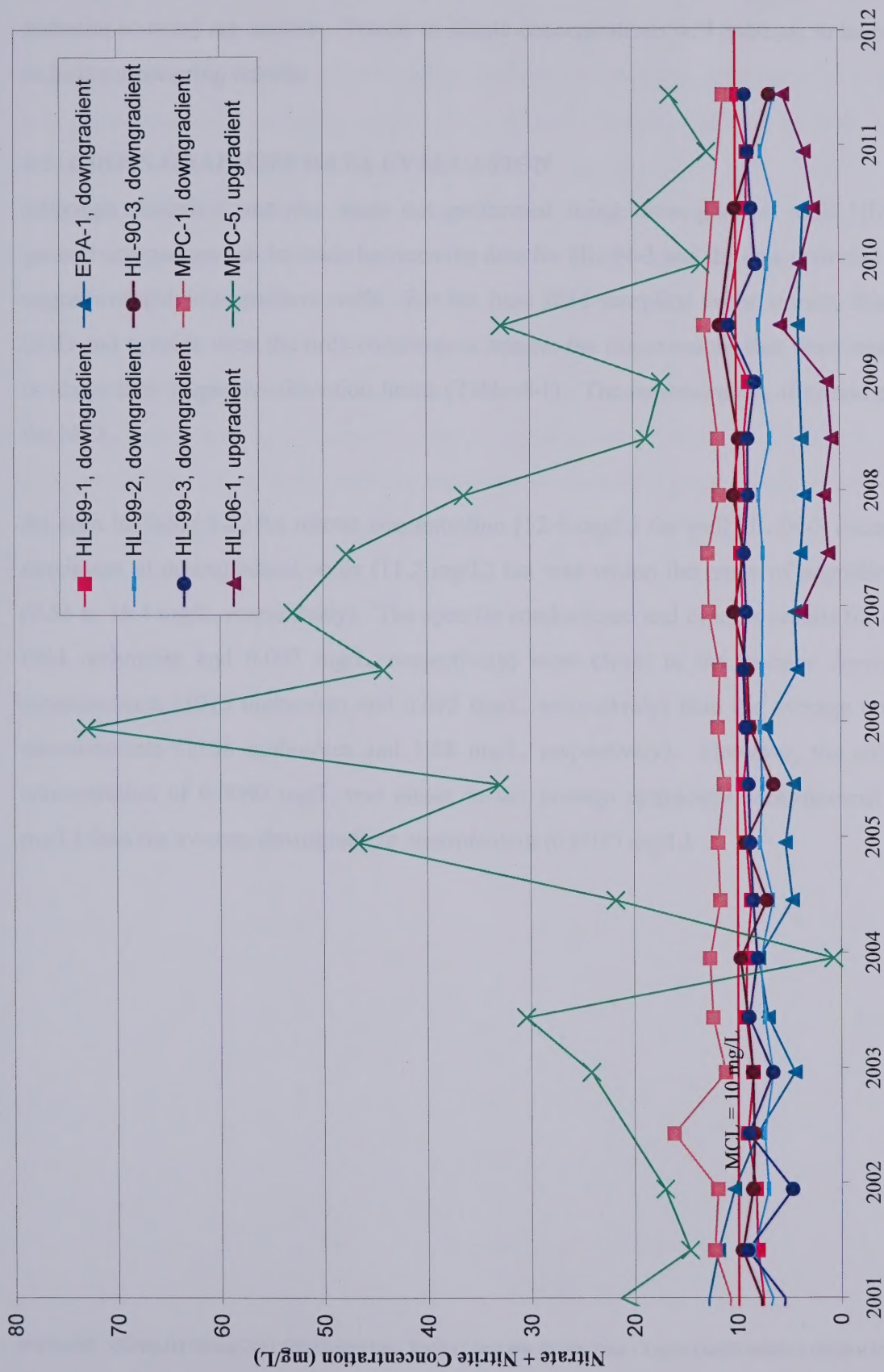


Figure 4-2. Temporal Trends in Nitrate Concentrations at Selected Monitoring Wells

wells, the effects of the landfill on groundwater nitrate concentrations (relative to other potential sources) are unclear. Trends in nitrate concentrations will continue to be evaluated in future monitoring reports.

4.5 CROSS-GRADIENT DATA EVALUATION

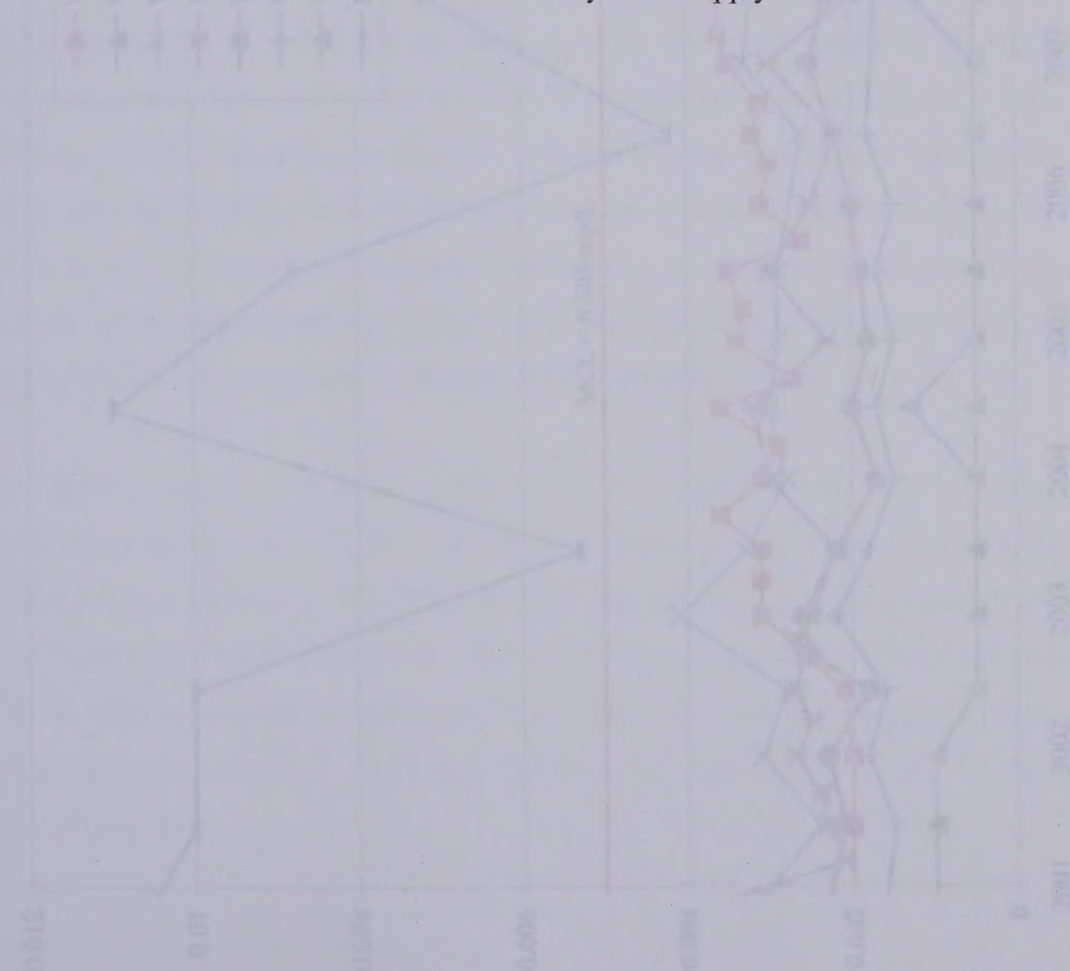
Although statistical analyses were not performed using cross-gradient well HL-94-3, a general comparison can be made between the data for HL-94-3 and the data collected for both upgradient and downgradient wells. For the June 2011 sampling event, nitrate, chloroform, COD and cyanide were the only constituents besides the major anions that were measured at or above their respective detection limits (Table 4-1). The concentration of nitrate exceeded the MCL.

As seen in Table 3-2, the nitrate concentration (12.4 mg/L) for well HL-94-3 exceeded the maximum of downgradient wells (11.2 mg/L) but was within the range of upgradient wells (0.54 to 16.4 mg/L, respectively). The specific conductance and cyanide results for HL-94-3 (944 umhos/cm and 0.097 mg/L, respectively) were closer to the average downgradient measurements (1015 umhos/cm and 0.092 mg/L, respectively) than the average upgradient measurements (1288 umhos/cm and 1.88 mg/L, respectively). However, the chloroform concentration of 0.0040 mg/L was closer to the average upgradient measurement (0.0049 mg/L) than the average downgradient measurement (0.0015 mg/L).

5. IRRIGATION WELL AND DOMESTIC WELL DATA EVALUATION

One irrigation well, the infiltration gallery and seven domestic wells were also sampled during the June 2011 sampling event. The infiltration gallery and well 62 had no VOCs reported above the detection limits. For wells 5, 16, 40, 48, 52, 57, and 90, the only concentrations of VOCs reported above the detection limit were for chloroform and PCE; all detections were below their respective MCLs. Irrigation well I-4 had measurable concentrations of 1,1-dichloroethane in addition to chloroform and PCE. All detections were below the MCLs. Trends in PCE concentrations over the last ten years for the sampled domestic and irrigation wells are shown on Figure 5-1. Using the Mann-Kendall test, PCE results in I-4 are showing a statistically significant downward trend (test results are included in Appendix B). All of these wells are used only for irrigation and all homeowners of these domestic wells have been connected to the City water supply.

Figure 5-1. Temporal Trends in PCE Concentrations



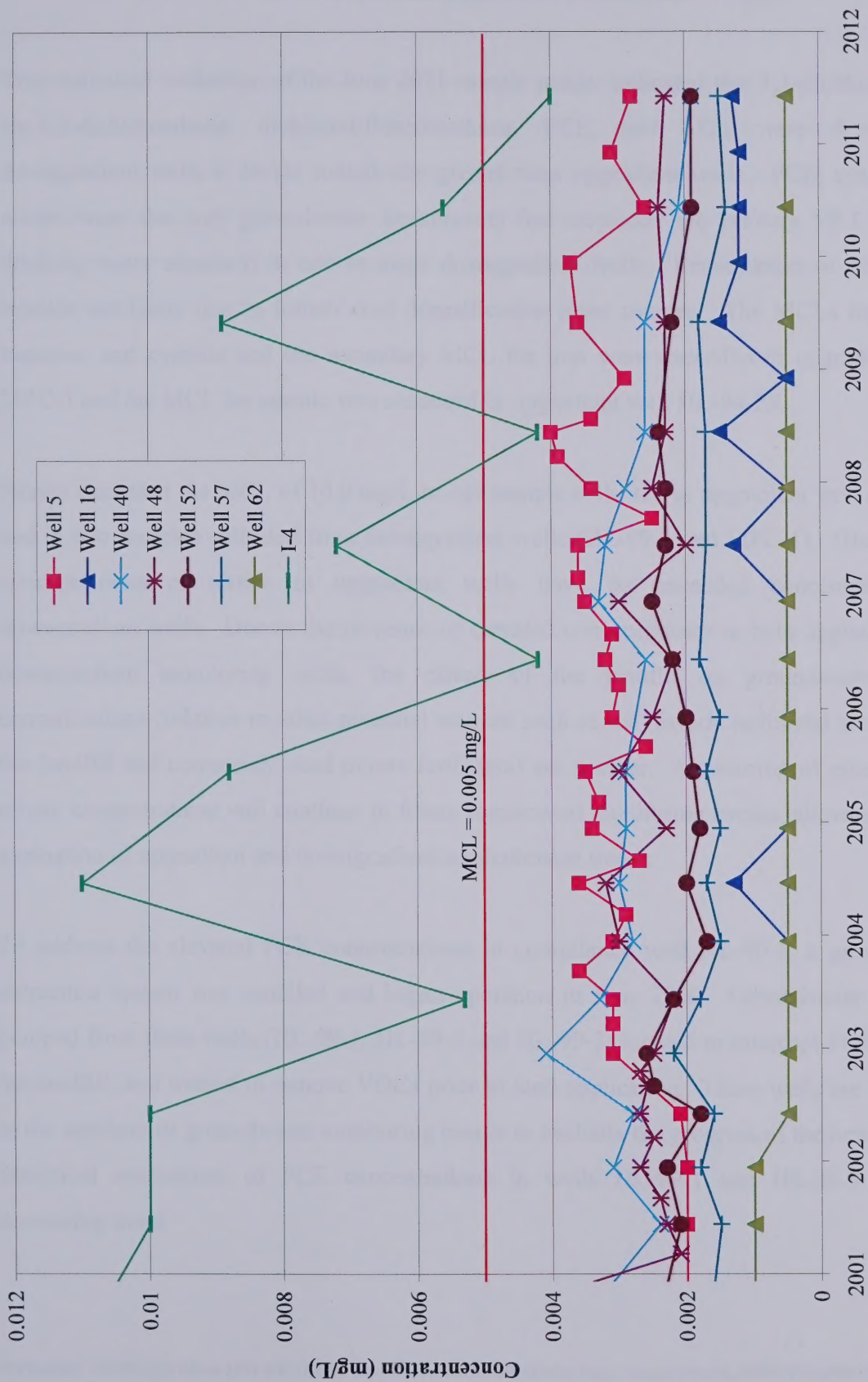


Figure 5-1. Temporal Trends in PCE Concentrations in Domestic and Irrigation Wells

6. SUMMARY AND CONCLUSIONS

This statistical evaluation of the June 2011 sample results indicated that 1,1-dichloroethene, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, and TCE were detected in downgradient wells at levels statistically greater than upgradient wells. PCE, cyanide and nitrate were the only groundwater constituents that exceeded the primary MCL (federal drinking water standard) in one or more downgradient wells. Exceedances of nitrate and cyanide are likely due to former coal degasification plant sources. The MCLs for nitrate, benzene, and cyanide and the secondary MCL for iron were exceeded in upgradient well MPC-5 and the MCL for arsenic was exceeded in upgradient well HL-94-2R.

Nitrate exceeded the MCL of 10.0 mg/L in one sample collected in upgradient well (MPC-5) and in two samples collected from downgradient wells (HL-99-1 and MPC-1). Historically, concentrations of nitrate in upgradient wells have far exceeded concentrations in downgradient wells. Due to the presence of elevated concentrations in both upgradient and downgradient monitoring wells, the effects of the landfill on groundwater nitrate concentrations (relative to other potential sources such as the historic industrial area east of the landfill and commonly used nitrate fertilizers) are unclear. Monitoring of groundwater nitrate concentrations will continue in future semiannual monitoring events, allowing further evaluation of upgradient and downgradient concentration trends.

To address the elevated PCE concentrations in compliance well HL-90-1, a groundwater extraction system was installed and began operation in June 2000. Groundwater is being pumped from three wells (HL-99-1, HL-99-2 and HL-99-3) located to intercept PCE leaving the landfill, and treated to remove VOCs prior to land application. These wells are included in the semiannual groundwater monitoring events to evaluate the progress of the new system. Statistical evaluations of PCE concentrations in wells HL-99-1 and HL-99-3 show a decreasing trend.

PCE exceeded the federal MCL in downgradient wells HL-10-1, MPC-1 and HL-99-3. Well HL-10-1 was installed in May 2010 immediately adjacent to compliance well HL-90-1. The concentration of PCE in well HL-10-1 is within historical range of HL-90-1 concentrations and since concentrations in well HL-90-1 were decreasing with time, a similar trend is predicted for well HL-10-1. According to the potentiometric map in Figure 2-2, groundwater flow through well MPC-1 heads directly for the groundwater extraction and should be extracted and treated. Concentrations of PCE in extraction well HL-99-3 show a statistically decreasing trend.

7. REFERENCES

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DATA VALIDATION REPORT CITY OF HELENA LANDFILL

Groundwater Samples Collected by

June 2011

(City of Helena Landfill)

APPENDIX A

DATA VALIDATION REPORT

Prepared by
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August 2011

TABLE OF CONTENTS

LIST OF APPENDICES	ii
GLOSSARY OF TERMS	iii
SUMMARY	1
1. INTRODUCTION	2
2. DELIVERABLES	4
3. FIELD QUALITY CONTROL SAMPLES	5
4. LABORATORY PROCEDURES	5
5. DETECTION LIMITS	6
6. LABORATORY BLANKS	6
7. LABORATORY BLANK SPIKES	7
8. NONDATE SPIKES	7
9. MATRIX SPIKE / MATRIX SPIKE DUPLICATES (MS/MSD)	7
10. INTERPARAMETER RELATIONSHIPS	8
11. HISTORICAL COMPARISON	9
12. DATA QUALITY OBJECTIVES	9
REFERENCES	10

DATA VALIDATION REPORT **CITY OF HELENA LANDFILL**

Groundwater Samples Collected in

June 2011

(Semi-Annual Sampling)

Prepared by
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LIST OF APPENDICES

APPENDIX 1: TABLES

TABLE 1 - Data Validation Codes and Definitions
TABLE 2 - Historical Comparison
TABLE 3 - Summary of Flagged Data

APPENDIX 4: DATABASE

AUGUST 2011

APPENDIX 5: HYDROMETRICS FIELD NOTES

APPENDIX 6: HYDROMETRICS ANALYTICAL REPORT

TABLE OF CONTENTS

LIST OF APPENDICES.....	II
GLOSSARY OF TERMS	III
SUMMARY	1
1. INTRODUCTION	3
2. DELIVERABLES.....	4
3. FIELD QUALITY CONTROL SAMPLES.....	5
4. LABORATORY PROCEDURES	5
5. DETECTION LIMITS	6
6. LABORATORY BLANKS	6
7. LABORATORY BLANK SPIKES	7
8. SURROGATE SPIKES.....	7
9. MATRIX SPIKE /MATRIX SPIKE DUPLICATES (MS/MSD)	7
10. INTERPARAMETER RELATIONSHIPS.....	8
11. HISTORICAL COMPARISON.....	8
12. DATA QUALITY OBJECTIVES.....	8
REFERENCES	10

LIST OF APPENDICES

APPENDIX 1: TABLES

TABLE 1 – Data Validation Codes and Definitions

TABLE 2 – Historical Comparison

TABLE 3 – Summary of Flagged Data

APPENDIX 2: DATABASE

APPENDIX 3: HYDROMETRICS FIELD NOTES

APPENDIX 4: ENERGY LABORATORIES ANALYTICAL REPORT

GLOSSARY OF TERMS

CCB	Continuing Calibration Blank
CCV	Continuing Calibration Verification
CLP	Contract Laboratory Program
CRDL	Contract Required Detection Limit
FAA	Flame Atomic Absorption
GFAA.....	Graphite Furnace Atomic Absorption
HGAA.....	Hydride Generation Atomic Absorption
ICB	Initial Calibration Blank
ICP	Inductively Coupled Plasma
ICV	Initial Calibration Verification
IDL	Instrument Detection Limit
LCS	Laboratory Control Sample
MSA.....	Method of Standard Additions
PB.....	Preparation Blank
PRDL	Project Required Detection Limit
QAPP	Quality Assurance Project Plan
QC	Quality Control
RPD.....	Relative Percent Difference
RSD.....	Relative Standard Deviation
SOW.....	Statement of Work
TDS	Total Dissolved Solids

SUMMARY

Laboratory analysis for groundwater samples collected for the June 2011 sampling event as part of the City of Helena Landfill have been reviewed and validated. This review has been in accordance with the "Revised Sampling and Analysis Plan; City of Helena Landfill; Groundwater, Surface Water, and Landfill Gas Monitoring Activities" (Hydrometrics, March 2008). All samples were analyzed at Energy Laboratories in Helena, Montana.

Data results are qualified when associated field quality control samples have not met validation criteria. Not all quality control deficiencies are equally serious and some may not have any practical impact on the usefulness of the data. A summary of quality control violations found in this validation follows:

Violations involving field quality control samples:

- In the field duplicate pair, HL-1106-106 and HL-1106-107 (HL-90-3), one exceedance occurred for chemical oxygen demand resulting in four associated data being flagged.

Violations involving laboratory quality control samples:

- In the QA/QC Summary Report provided by Energy Laboratories, matrix spike and matrix spike duplicate review showed several exceedances. However, at this level of validation, laboratory exceedances are noted but no flagging of the data occurs.
- It should also be noted that Energy Laboratories raised the reporting limit of sulfate, nitrate + nitrite as n, chloride, and cyanide due to sample matrix interference. The reporting limits used for dissolved antimony and thallium were lower than the requested limits, and did not seem to impact the results.
- Energy Laboratories exceeded the holding time for pH for all samples submitted. However, as a rule holding times for laboratory pH measurements are frequently exceeded because measurements are typically not conducted "immediately", but rather as soon as practicable. Therefore, no qualifiers are applied for lab pH holding time exceedances.
- It should be noted that Energy Laboratories used a different method than stated in the work plan on the following parameters: pH, SC, and cyanide. However, no associated

data was flagged because the methods used are considered comparable to stated methods in work plan.

Deviations from the prescribed quality control procedures and/or exceedances of quality control limits have been noted, and results have been flagged in the database. The data quality objectives for accuracy and precision were met, as 99 percent of the field quality control sample results were within control limits and 97 percent of the laboratory quality control samples were within limits. The frequency requirements of 10 percent submittal of blanks, duplicates, control standards and spikes were met. The recommended project completeness goal, acceptance of 90 percent of the results as valid, has also been met as no results have been rejected as a result of this data review. Further discussion of data quality objectives is in Section 12 of the data validation report. All tables are in Appendix 1: data validation codes and definitions are listed in Table 1; a brief summary of flagged data is in Table 2; and a historical comparison is in Table 3. A database printout of this sampling event is located in Appendix 2. The Hydrometrics field notes are in Appendix 3. Energy Laboratories Analytical Reports are located in Appendix 4.

14	HL-1106-124				
15	HL-1106-125				
16	HL-1106-126				
17	HL-1106-127				
18	HL-1106-128				
19	HL-1106-129				
20	HL-1106-130				
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84	HL-1106-194				
85	HL-1106-195				
86	HL-1106-196				
87	HL-1106-197				
88	HL-1106-198				
89	HL-1106-199				
90	HL-1106-200				

- 1.1. Field-generated data are in the HL-1106-100 to HL-1106-200 range.
- 1.2. Laboratory-generated data are in the HL-1106-201 to HL-1106-300 range.
- 1.3. Data in the HL-1106-301 to HL-1106-400 range are in the HL-1106-301 to HL-1106-400 range.

DATA VALIDATION REPORT

1. INTRODUCTION

This validation applies to organic analytes for 32 water samples collected for the City of Helena Landfill semi-annual monitoring project during the June 2011 sampling event. The total number of samples included: five field observations, one field duplicate, two field blanks (DI and Rinsate) and one trip blank.

All samples were submitted for volatile organic analyses, and select samples were submitted for inorganic analyses (metals and wet chemistry) as follows:

SITE CODE	SAMPLE NUMBER	WATER LEVEL	FIELD PARAMETERS ¹	METALS AND COMMONS ²	VOLATILES METHOD 8260 ³
INF GALLERY	HL-1106-100	X	X		X
MPC-2	HL-1106-101	X	X		X
Res #16	HL-1106-118		X		X
Res #5	HL-1106-125		X		X
Res #90	HL-1106-126		X		X
Res #40	HL-1106-119		X		X
Res # 57	HL-1106-121		X		X
Res #52	HL-1106-120		X		X
Res #48	HL-1106-122		X		X
I-4	HL-1106-124		X		X
Res #62	HL-1106-123		X		X
HL-90-2	HL-1106-102	X	X	X	X
HL-06-1	HL-1106-105	X	X	X	X
HL-90-3	HL-1106-106	X	X	X	X
HL-90-3 DUP	HL-1106-107			X	X
HL-94-1	HL-1106-103	X	X	X	X
HL-94-2R	HL-1106-108	X	X	X	X
HL-94-3	HL-1106-104	X	X	X	X
HL-90-1	HL-1106-131	X			
MPC-1	HL-1106-112	X	X	X	X
DI BLANK	HL-1106-111			X	X
EPA-1	HL-1106-113	X			
MPC-5	HL-1106-114	X	X	X	X
HL-99-1	HL-1106-115	X	X	X	X
HL-10-01	HL-1106-109	X	X	X	X
HL-99-2	HL-1106-116	X	X	X	X
HL-99-3	HL-1106-117	X	X	X	X
RINSATE BLANK	HL-1106-110			X	X
TRIP BLANK	HL-1106-127				X
I-1	HL-1106-128	X			
82-3	HL-1106-129	X			
EPA-2	HL-1106-130	X			

- 1.) Field parameters include pH, SC, and water temperature.
- 2.) Metals and commons include those compounds listed in the first half of ARM 17.50.708 Table 1.
- 3.) Volatile organic compounds include those listed in the second half of ARM 17.50.708 Table 1.

- Validation procedures used are generally consistent with:

(Check all that apply)

- ☒ EPA CLP National Functional Guidelines for Inorganics Data Review
- ☒ EPA CLP National Functional Guidelines for Organic Data Review
- ☒ Work Plan (Sampling and Analysis Plan, City of Helena Landfill Groundwater Monitoring Activities, Hydrometrics, March 2008)

- Overall level of validation:

- ☐ Contract Laboratory Program (CLP)
- ☒ Standard (see following notes)
- ☐ Visual

NOTES: The review of this data includes checking all field and laboratory quality control samples; flagging for exceedances in field quality control; and calculating precision, accuracy, and completeness for both laboratory and field quality control samples.

2. DELIVERABLES

- All laboratory document deliverables were present as specified in the CLP-Statement of Work (CLP-SOW), EPA, 1993 and/or the project contract.

- ☒ Yes (see following notes)
- ☐ No

NOTES: The following was noted on the Workorder Receipt Checklist upon samples arrival at Energy Labs;

- Sample HL-1106-108 did not have a collection time on the sample containers – time was used off the Chain of Custody.
- Sample HL-1106-107 had the three HCL preserved VOAs that were broken upon check in and three unpreserved VOAs were received intact. Energy Labs analyzed 8260 with unpreserved VOAs per Rick Lane.
- The COC for sample HL-1106-117 indicates six VOAs however only three were received.
- For sample HL-1106-118 the COC indicates that three VOAS were received however six VOAs were received.
- HL-1106-111 one of the HCL preserved VOAs was broken in lab accident.

- All documentation of field procedures was provided as required.

- ☒ Yes
- ☐ No

- Consistency with project requirements

Sampling was completed in order as stated in the SAP.

- ☒ Yes (see following notes)
- ☐ No

NOTES: It should be noted that the wells were not sampled in the order listed in the SAP. The order of sampling was followed for all wells that do not use dedicated or disposable equipment. Any variances in sampling order were noted in the field book.

3. FIELD QUALITY CONTROL SAMPLES

- **Field blanks**

Please note that the highest blank value associated with any particular analyte is the blank value used for the flagging process.

DI, trip, rinsate, or any other field blanks have been carried out at the proper frequency.

☒ Yes

☐ No

Reported results on the field blanks are less than the contract required detection limits (CRDL) or the project required detection limits (PRDL) if project detection limits have been specified.

☒ Yes

☐ No

- **Field duplicates**

Field duplicates have been collected at the proper frequency.

☒ Yes

☐ No

Field duplicate relative percent differences (RPD's) were within the required control limits (RPD of 20 percent or less for water matrix, 35 percent or less for soil matrix). If the sample or duplicate result is less than 5 times the PRDL, the RPD criteria are not used. In these cases, the difference between the sample and the duplicate results must be within $\pm$ the PRDL for water matrix, within $\pm$ 2 times the PRDL for soil matrix.

☐ Yes

☒ No (see the following notes)

NOTES: In field duplicate sample pair, HL-1106-106 and HL-1106-107 (HL-90-3), one exceedance occurred for chemical oxygen demand resulting in four associated results being flagged.

- **Field standards**

Field standards were sent at the proper frequency

☐ Yes

☐ No

☒ NA - Not required by the work plan.

4. LABORATORY PROCEDURES

- **Laboratory procedures followed**

☐ CLP-SOW

☒ SW-846

☒ Methods for Chemical Analysis of Water and Wastes

☐ XRF Standard Operating Procedures

☐ Other

- **Samples were received by the laboratory at the proper temperature**

☒ Yes

☐ No

- **Holding times met**

☐ Yes

☒ No (see the following notes)

NOTES: Energy Laboratories exceeded the holding time for pH for all samples submitted. However, as a rule holding times for laboratory pH measurements are frequently exceeded because measurements are typically not conducted "immediately", but rather as soon as practicable. Therefore, no qualifiers are applied for lab pH holding time exceedances.

- **Consistency with project requirements**

Analyses were carried out as requested.

☒ Yes (see following notes)

☐ No

NOTES: Upon receipt of the Analytical Summary Report it was noted that the Nitrate + Nitrate as n results were not near historical levels; therefore, E. Vallance with Hydrometrics contacted Energy Laboratories – Helena regarding the work order as correction action was needed. It was requested that the Nitrate +Nitrite as N analysis be re-analyzed for all samples in this event to confirm results. The reported Nitrate + Nitrite as n was revised for samples H11060293-009 through H11060293-012 (HL-1106-114 through HL-1106-117) as the original result was missing a dilution factor from the Nitrate + Nitrite as n when reported.

Project specified methods were used.

☒ Yes (see following notes)

☐ No

NOTES: It should be noted that Energy Laboratories used a different method than stated in the work plan on the following parameters: pH, SC, and cyanide. However, no associated data was flagged because the methods used are considered comparable to stated methods in work plan.

5. DETECTION LIMITS

- Reporting detection limits met project required detection limits (PRDL).

☒ Yes (see following notes)

☐ No

NOTES: It should be noted that Energy Laboratories raised the reporting limit for sulfate, nitrate + nitrite as n, chloride, and cyanide due to a sample matrix interference. The reporting limits used for dissolved antimony and thallium were lower than the requested limits, and did not seem to impact the results.

6. LABORATORY BLANKS

Please note that the highest blank value associated with any particular analyte is the blank value used for the flagging process.

- **Preparation/Method blanks**

Preparation/Method blanks were prepared and analyzed at the required frequency.

☒ Yes

☐ No

All analytes in the preparation blank were less than the CRDL (or PRDL if a project detection limit has been specified).

☒ Yes

☐ No

7. LABORATORY BLANK SPIKES

- **Blank Spikes**

Blank spikes (organics) were prepared and analyzed at the required frequency.

☒ Yes

☐ No

Blank spike recoveries were within control limits.

☒ Yes

☐ No

8. SURROGATE SPIKES

- **Surrogate Spikes**

Surrogate spikes were prepared and analyzed at the required frequency.

☒ Yes

☐ No

Surrogate spike recoveries were within control limits.

☒ Yes

☐ No

9. MATRIX SPIKE /MATRIX SPIKE DUPLICATES (MS/MSD)

- Matrix spike samples were analyzed at the proper frequency.

☒ Yes

☐ No

Matrix spike recoveries were within control limits.

☐ Yes

☒ No (see following notes)

- Matrix spike duplicate samples were analyzed at the proper frequency.

☒ Yes

☐ No

Matrix spike duplicate RPD's were within control limits.

☐ Yes

☒ No (see following notes)

NOTES: Both matrix spike and matrix spike duplicate samples had several QC exceedances. At this level of validation, these exceedances are only noted and no flagging of the associated data occurs.

10. INTERPARAMETER RELATIONSHIPS

- The following relationships have been checked for all data from the June 2011 monitoring:

☒ Lab SC versus field SC

☒ Lab pH versus field pH

Lab SC versus field SC: A comparison of the field and lab SCs using a percent difference (%D) criteria for evaluation purposes, showed that one of the SC pairs exceeded the ten percent comparison criteria.

Lab pH versus field pH: A comparison of the field and lab pHs using a percent difference (%D) criteria for evaluation purposes, showed that also one of the pH pairs exceeded the ten percent comparison criteria.

11. HISTORICAL COMPARISON

Current sampling event data (June 2011) were compared to historical data (June 2007 through May 2011). The data for the June 2011 sampling event was similar to historic data.

12. DATA QUALITY OBJECTIVES

- Project data quality objectives (DQO's) met.

☒ Yes

☐ No

Accuracy

Accuracy for this project is the agreement between a measured value and a true value and is measured by the recoveries on the laboratory matrix spikes and laboratory control samples.

Accuracy for this sampling event was 99 percent.

Precision

Precision for this project is the degree of variability between duplicate measurements. Laboratory analytical variability is measured by laboratory duplicates; field duplicates are a measure of overall variability in both field sampling and laboratory techniques.

Laboratory precision was 97 percent for this sampling event.

Field precision was 99 percent for this sampling event.

Completeness

The target completeness for this project is 90 percent of the measurements valid (not rejected). This percentage is based on the number of valid measurements compared to the number of planned measurements. Completeness for this sampling event was 100 percent.

DATA VALIDATION REPORT

Prepared by: **Ericka Vallance**

Reviewed by: **Jodi Bingham, P.E.**

REFERENCES

- Hem, J.D., 1992. Study and Interpretation of the Chemical Characteristics of Natural Water, 3rd Edition. US Geological Survey Water Supply Paper 2254.
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Data Validation and Statistics
Evaluation of June 2011
Groundwater Quality Data

City of Helena Landfill
Appendix A - Data Validation (Appendices Only)

August 2011



HYDROMETRICS

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APPENDIX B

STATISTICAL ANALYSIS REPORTS

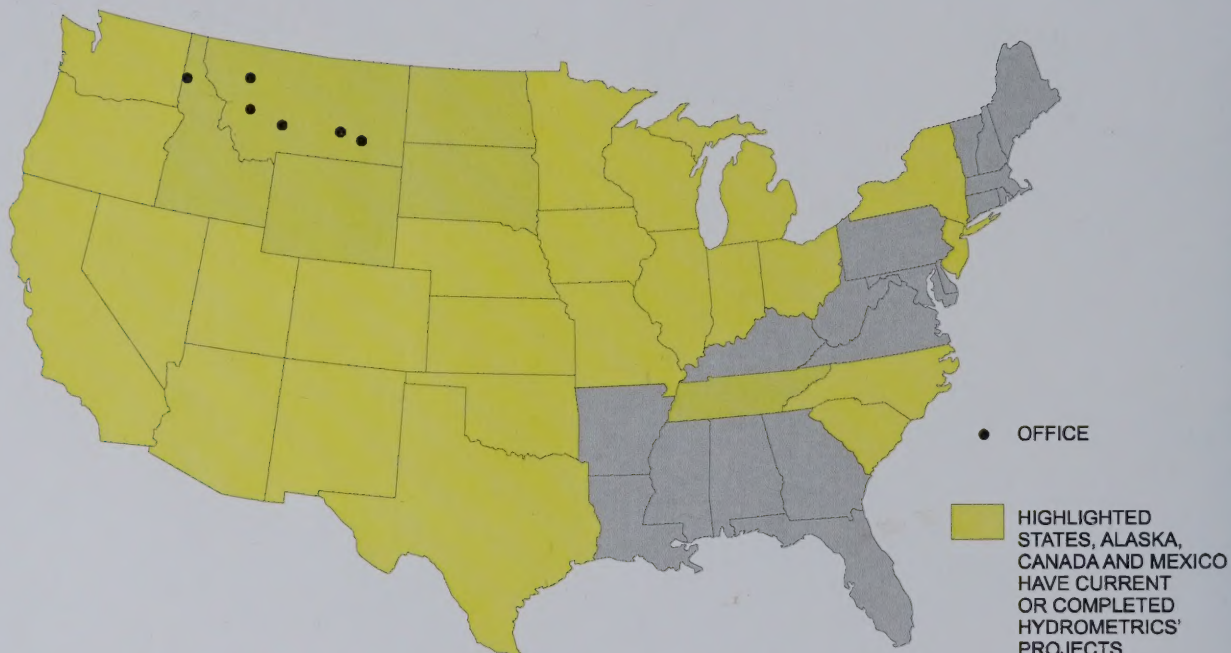
and Validation and Statistical
Evaluation of June 2011
Groundwater Quality Data

City of Helena Landfill
Appendix B - Statistical Analysis Reports

August 2011

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